XXV. *Notes on the Generative Organs, and on the Formation of the Egg in the Annulosa.* *By* JOHN LUBBOCK, *Esq.*, *F.R.S.*

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MYRIAPODS.

THROUGH the labours of BRANDT, FABRE, NEWPORT, STEIN, TREVIRANUS, and other eminent naturalists, we are tolerably well acquainted with the anatomy of the generative organs in the Myriapods; but these observers have occupied themselves principally with the arrangement and forms of the organs, and have not paid much attention to the different stages of egg-development, nor to the relation in which the young egg stands with reference to the surrounding tissues. This relation is indeed very curious, and seems to have been generally misunderstood. It is well known that the Myriapods have not long egg-tubes, as is the case with most insects, but that each egg arises in a separate follicle. It was, however, natural to suppose that this follicle held the same position with reference to the ovary as the very similar egg-follicles of certain insects, as, for instance, of *Coccus*. This, however, is by no means the case. In Plate XVII. fig. B, I have given a diagrammatic section of the ovary of *Coccus*, with a single egg-follicle (*a*), the vitelligenous cells being represented at *b*, and the Purkinjean vesicle at *c*.

If, now, we compare with this a similar diagram of the ovary in *Glomeris* (Plate XVII. fig. A), also with a single egg-follicle, we shall see that this latter is very much alike in both cases—the shape of the egg-follicle (*a*), the Purkinjean vesicle (*c*), and the vitelligenous bodies (*v*) being very similar; but whereas in *Coccus* and in all insects the egg-follicle projects *from* the ovary, in *Glomeris* and the other Myriapods, so far as my observations go, the follicle projects *into* the ovary. If, therefore, we consider the ovary as consisting of an outer membrane (*d*) and an inner epithelial layer (*e*), it would appear that while the egg in the Myriapods arises between these two layers, in the insects it originates on the inner side of both.

This difference appears to me to be very important, and, as will be mentioned under the head of *Iulus*, escaped the attention of our great anatomist NEWPORT, and led him to give an erroneous description of the ovary in that genus. I have chosen to compare *Glomeris* with *Coccus* in the above-mentioned diagrams, because the vitelligenous bodies make the resemblance of, and at the same time the difference between, these two genera more striking. If, however, we compare with them a similar diagram of the ovary of *Phalangium* (Plate XVII. fig. C), we shall see, not only that the vitelligenous bodies are absent, but that the egg-follicle differs equally from that of the insect on the one hand, and that of the Myriapod on the other. The egg-follicle projects *from* the

ovary as in *Coccus*, &c.; but, on the other hand, the Purkinjean vesicle lies on the outer side of the epithelial layer (*d*), as in *Glomeris*, and in consequence the egg-follicle, which in *Coccus* consists of both the ovarian membranes (so far as the epithelial layer can be called a membrane), and in *Glomeris* of the epithelial layer only, is in the Phalangidæ, and perhaps all the Arachnida, formed only by the outer membrane. Consequently, while in the insects the mature ovum passes into the ovary through the neck of the follicle, in Myriapods and the Arachnida it bursts through the epithelial layer, in the former at its free, and in the latter at its attached end.

If these characteristics are found eventually to hold good throughout the Myriapods and Arachnida, the differences thus shown to exist between these groups will be of great interest; but it is too early to generalize on the subject with much confidence. Moreover, it often happens that one or a few epithelial cells *are* attached in Arachnida to the inner side of the follicle-wall. This happens, however (so far as my observations go), without any regularity, and the cells thus present fulfil perhaps no important function in the formation of the egg. The Crustacea* appear to differ from the three preceding groups in the fact that their eggs do not possess separate follicles. The nuclei of the epithelial cells in the ovary of *Oniscus* are about $\frac{2}{8000}$ths of an inch in diameter, with a bright nucleolus; but along the inner edge of the ovary one or two may generally be found as much as $\frac{6}{8000}$ths of an inch in diameter, but not otherwise differing from the small ones. Between these extremes all intermediate stages may with patience be discovered.

When the epithelial nucleus has attained the above size, or even a little earlier, a deposit of dark, structureless matter appears round it. This is the commencement of the yelk, and has at first no bounding membrane, as the membrane of the cell itself seems to perish at a very early stage. It soon, however, acquires a clearly marked outline, though it is not until it is full-grown that any true membrane is formed round it. The outline is, however, so clear and sharp that it is often difficult to believe that there is in reality no membrane. Pressure, however, clearly shows that there is none.

In *Ligia oceanica* the process is almost exactly similar; and although the animal is so much larger, the epithelial cells, their nuclei, and the young Purkinjean vesicles are as nearly as possible of the same size as in *Oniscus*.

* To M. Schöbl (Zeitschrift für Wiss. Zool. 1860, p. 465) is, I believe, due the credit of being the first to describe the position of the female orifice and the presence of a spermatheca in the Oniscidæ. I had myself independently made the same observations in *Oniscus* as he has in his new genus *Haplophthalmus*, and can therefore confirm what he says on the subject, though the size of the eggs is so great, compared with that of the orifice, that I am still at a loss to understand how they make their exit. M. Schöbl found the spermatheca full of spermatozoa in May only, but in *Oniscus* I found them in January, February, June, and August, the only months in which I looked for them. They were always motionless, and I never found in the female any of the large round cellular bodies which occur in the generative organs of the male. The spermatozoa were not confined to the spermatheca, but I met with them also in the oviduct, and even frequently (if not always) in the ovary itself.

LEUCKART* has already noticed a remarkable vesicle which was observed by him in the yelk of *Geophilus*. I have not convinced myself as to the presence of any such body in that genus, but have observed a vesicle constantly present in the yelk of *Arthronomalus*, a genus which is closely allied to *Geophilus*, and which was probably the subject of LEUCKART'S examination. A smaller vesicle, probably however of a similar nature, also occurs in *Lithobius*, and a still more rudimentary structure also appears to exist in *Iulus*. In *Glomeris*, as already mentioned, vitelligenous cells, not unlike those of *Coccus*, are present.

CHILOGNATHS.

Glomeris marginata, Plate XVI. figs. 1, 2, 3.—In this species, and probably in all the Chilognaths, there are two vulvæ, which are situated in the third segment, and open into two short egg-canals. These soon unite into a common oviduct, which again in its turn quickly expands into a large, simple, cylindrical ovary. This ovary extends in a straight line back nearly to the posterior pair of legs, and lies immediately below the intestinal canal. It is extremely delicate, and so transparent that it might easily be overlooked if it was not rendered conspicuous by the opake whiteness of the eggs contained in it. These, however, are not produced indiscriminately over the whole surface of the ovary, but only along two ribbon-shaped parts which run along the lower lateral portions of the ovary, almost from one end to the other, and thus leave the whole of the upper wall of the ovary, the sides, and a narrow strip along the middle of the ventral surface quite free from eggs. When the egg-germs are still quite small, these two "stromas" have the appearance of two separate ovaries; and it is probable that, as M. FABRE has suggested in his excellent memoir "Sur l'anatomie des organes reproducteurs et sur le développement des Myriapodes†," it is from having examined the animal at this stage, and from having overlooked the ovarian walls, that the earlier observers were led to describe the organ as being double‡.

The follicles in which the eggs are developed also probably contributed in no small degree to this error, since they do not project, as one would naturally expect they would do, from the outer surface of the ovary, but, on the contrary, protrude into its central cavity; so that even if the delicate walls of the ovary are perceived, they may easily be mistaken for a band of some tissue intended to keep the two supposed ovaries in their place. The walls of the follicle consist of nucleated epithelial cells (Plate XVI. fig. 1), and each follicle contains only a single egg. The follicle is at first small, but grows in size as the egg-matter contained in it increases in volume, and takes an elongated

* Art. Zeugung.

† Annal. des Sci. Nat. 1855.

‡ See TREVIRANUS, Verm. Schr. p. 45, who, however, has correctly seen the two strings of eggs; BRANDT, MÜLLER'S Archiv, p. 837; and STEIN, MÜLLER'S Archiv, 1842, p. 248. M. FABRE, though he has correctly explained the relation of the different parts, still describes the ovary as double, since he denies the name of ovary to the central sac, and applies it only to the two stromas, in which, according to him, the eggs are formed. It is not, however, quite correct to say that the eggs are formed in the stromas, since in reality they arise in follicles which are only attached to the stroma by their base.

oval form. At the free end of each follicle, opposite its place of attachment to the stroma, is a place deficient in epithelial cells, the space being apparently occupied by a thick layer of some amorphous substance.

The specimens which I examined in July and August contained some eggs $\frac{1}{50}$th of an inch in diameter, and of an opake white appearance, with others in all earlier stages of development.

I was not able to ascertain with certainty the origin of the Purkinjean vesicle; but in the youngest egg-follicle it only differed in size and in the solid appearance of the nucleus from the ordinary epithelial cell. I have therefore little doubt that the Purkinjean vesicle is a modified epithelial cell, and that the "macula" of WAGNER is homologous with its nucleus. The smallest Purkinjean vesicle I observed was $\frac{1}{2600}$th of an inch in diameter, the follicle itself being only about double the size. The macula was distinctly visible; and neither in this one, nor in others rather more advanced, could I see the vitelligenous bodies.

The young egg-follicles, at a somewhat later stage, strikingly resemble those of *Coccus* before the constriction has commenced and when the epithelial cells are not very conspicuous; and this similarity is the more striking because we find in *Glomeris* vitelligenous bodies (Plate XVI. figs. 1 & 2, *v*) like those of insects, and specially like those of *Coccus*. The size and number is certainly more variable, but not in any great degree, five or six being the largest, and three or four the commonest number, and the usual relative size being also that which is generally found in *Coccus*. The yelk-substance is at this period more or less clear and transparent, and no oil-globules have been formed in it, so that the Purkinjean vesicle and spot are easily seen (Plate XVI. fig. 1, *p*); the vitelligenous bodies, on the contrary, so nearly resemble the yelk-substance in colour and consistence, that only in a few instances their outlines can be perceived, and then only in part and with difficulty.

This apparent similarity, however, does not prove any real identity of composition, as may readily be shown by the addition of a little acetic acid. No sooner is this done, than the yelk-substance becomes considerably darkened; and as the vitelligenous bodies remain unaltered, the contrast makes them very clearly visible; so that if a number of egg-follicles are in the field of view, the difference which is thus effected in their appearance is very striking (Plate XVI. fig. 2). As usual, the acetic acid renders the cell-wall of the Purkinjean vesicle almost invisible, and wipes out, as it were, the macula; but the contrast of colour leaves the vesicle itself very plain.

Under this treatment the Purkinjean vesicle very much resembles a vitelligenous cell, though it is generally rounder; and if the acid has been very weak, the ghost, so to say, of a macula may still be perceived, and sometimes a very similar nucleus may be seen in some of the vitelligenous bodies. This very seldom happened; but I have figured one of the few cases observed, in Plate XVI. fig. 2. Perhaps, therefore, in *Glomeris* the vitelligenous body is homologous with the Purkinjean vesicle, and the nucleus of the one with the macula of the other. According, however, to MEYER'S observations, it

would appear that in insects, as the Purkinjean vesicle surrounds itself with a well-defined portion of yelk, the original vitelligenous nucleus also forms a pseudo-cell; so that the vitelligenous body of *Glomeris*, which corresponds with the Purkinjean vesicle, is also homologous with the nucleus of the vitelligenous pseudo-cell of insects.

The action of tartaric acid is much like that of acetic acid. Ammonia renders the macula invisible, and the Purkinjean vesicle almost invisible, but it does not make the yelk-matter dark. Water does not act energetically on these tissues.

When the egg-germ has attained a length of about $\frac{1}{100}$th of an inch, the vitelligenous bodies have gradually disappeared, and the yelk-substance begins to present, under transmitted light, a dark colour, like that which at an earlier stage it assumes under the action of acetic acid. The Purkinjean vesicle can still be seen indistinctly; but when the follicle has attained to a length of $\frac{1}{70}$th of an inch it has become quite opake, and the Purkinjean vesicle can only be seen after the application of pressure.

Up to this time, however, the yelk is surrounded by no vitelline membrane, and indeed the majority of the oil-globules seem to be produced in the stroma, and not in the egg-follicle itself. The yelk consists of a clear fluid, containing an immense quantity of small oil-globules, varying up to $\frac{1}{8000}$th of an inch, of which size there are a great number.

The largest follicles were about $\frac{8}{200}$ths of an inch in length, and contained eggs which were already surrounded by a firm chorion. On carefully tearing this open, the Purkinjean vesicle could generally be perceived. It was from $\frac{13}{2000}$ths to $\frac{17}{2000}$ths of an inch in diameter, spherical and transparent, but the wall was often, as it were, stained in places. When seen sideways this gave the effect of a patch, as in fig. 3; but when looked at from in front it could only be seen faintly, and had, under a high power, no definite outline.

The macula at this stage consisted generally, if not always, of two vesicles, one of them more than twice as large as the other. The latter, which is no doubt derived from the large one, first appears when the Purkinjean vesicle is about $\frac{8}{2000}$ths of an inch in diameter. Under the action of acetic acid it disappears, as does the large macula; and its occurrence is very constant, since I found it in every Purkinjean vesicle which was more than $\frac{10}{2000}$ths of an inch in diameter.

I did not find any mature eggs until the beginning of September; and even at this time many females did not contain any; and in all there were only a few eggs which had escaped from their capsules. These lay free in the cavity of the ovary or oviduct; they had a leathery chorion, and, like the eggs of insects, seemed to possess no second envelope. They are about $\frac{1}{25}$th of an inch in size, and of a broad elliptic shape.

I could find in them no trace of the Purkinjean vesicle, nor of the maculæ. The yelk consisted, 1st, of an apparently viscid substance; 2ndly, of minute molecules; and 3rdly, of oil-globules from $\frac{1}{10000}$th to $\frac{5}{10000}$ths of an inch in diameter. If they were

placed between two slips of glass, and these latter were rubbed together, the oil-globules ran into one another and took the form of rods, thus showing that they possessed no true membrane.

Iulus.—The most detailed account of the generative organs, and formation of the egg, in *Iulus*, is that given by Mr. NEWPORT, in his celebrated memoir "On the Organs of Reproduction and the Development of the Myriapoda *." Mr. NEWPORT correctly describes the ovary as consisting of an elongated bag, which "in the pregnant female is smooth and distended with ova that have passed into it from the ovisacs;" but he figures and describes these ovisacs as projecting freely from the outer side of the ovary, whereas, in fact, in *Iulus* as in *Glomeris*, the egg-follicles project *into* the free cavity of the ovary, and do not project from its outer surface. Mr. NEWPORT was perhaps led into this error partly by what he expected to see, but also partly, no doubt, by a misinterpretation of what he actually did see. The wall of the ovary is extremely delicate, and at the same time so firmly united to innumerable tracheæ, and to parts of the fatty tissue, that it is almost impossible to detach the organ without injury; but if the wall is pierced, the egg-follicles immediately make their way out of the orifice, and the organ takes on an appearance much like that represented in his fig. 5, plate 3. The egg-follicles do not, however, clothe the whole inner surface of the ovary, but in this genus, as in *Glomeris* and *Polydesmus*, are confined to two long ribbon-shaped parts which run along almost the whole length of the organ.

In examining the early stages of the formation of the egg in the follicle, Mr. NEWPORT unfortunately used specimens which had remained for twenty-four hours in rectified spirits of wine. In consequence, he describes the youngest egg-follicles, which were about $\frac{1}{1000}$th of an inch in diameter, as being "filled with very minute graniform cells of a uniform size (about $\frac{1}{10000}$th of an inch), slightly opake, and of a yellow colour." If, however, he had examined in water a freshly killed specimen, he would have found these follicles perfectly clear, transparent, and colourless, and the Purkinjean vesicle and macula much more conspicuous. In such follicles the yelk always seemed to me to be a clear fluid, without any cellular contents at all resembling the minute graniform cells described by Mr. NEWPORT. The smallest egg-follicles I have observed were about the same size as those mentioned by Mr. NEWPORT. It is only when they have attained the size of about $\frac{1}{200}$th of an inch in length, that they begin to grow dark from the deposition in their interior of a finely granular yelk.

When they are $\frac{1}{95}$th of an inch they have become quite opake; but the yelk-globules are still very small, not generally more than $\frac{1}{8000}$th of an inch in diameter. At this stage it is not easy to get a good view of the Purkinjean vesicle by crushing the egg, as, even if the vesicle is not itself destroyed, the yelk is so sticky that it is difficult to separate it sufficiently. This can, however, generally be effected by tearing the egg open carefully with two needles.

In this manner it can be ascertained that the macula is still single; but it generally

* Philosophical Transactions, 1841.

looks as if it contained one or more nuclei imbedded in a darker substance. Moreover, in addition to the large macula, which is generally more or less vesicular, there is a smaller one, as in *Glomeris*. This latter is perhaps to be compared with the small vesicular macula of *Acheta*.

In August the *Iuli* which I examined contained no mature eggs; so that they do not appear to be so forward as those of *Polydesmus*.

The cells forming the follicles, or at least their nuclei, could be well seen; and the cells themselves are indicated by small projections along the edges of the follicles, but their walls are so delicate that they can seldom be seen in a full view. From the mode of examination adopted by Mr. NEWPORT, the histological structure of the follicle-wall quite escaped his observation.

In the mature eggs the yolk contained, 1st, globules of all sizes up to $\frac{1}{1000}$th of an inch; 2ndly, greenish spherules $\frac{1}{8000}$th to $\frac{1}{5000}$th of an inch; and 3rdly, the usual intermediate substance. The large yelk-globules are quite round, but they are not liquid, and on applying pressure they split at the edges. Sometimes a globule has a single fissure; but very often the splits radiate from the centre, or rather proceed inwards from the edges towards the centre.

In mature eggs Mr. NEWPORT saw a "transparent globular vesicle," which he assumed to be the "proper germ-vesicle considerably enlarged;" this, however, is certainly a mistake, since the true Purkinjean vesicle has always disappeared by the time the egg is full-grown; and the vesicle in question is therefore probably the embryo-cell. As regards the final lot of the Purkinjean vesicle, I have as little in *Iulus* as in the other Myriapods been able to come to any satisfactory conclusion. The largest eggs in which I could satisfactorily see the Purkinjean vesicle were about $\frac{3}{200}$ths of an inch in diameter; and the largest vesicles were about $\frac{1}{200}$th of an inch in diameter, clear, transparent, and with a single nucleus. The macula in *Iulus* does not, therefore, break up into numerous smaller maculæ, as is the case in *Lithobius* and, according to WITTICH, also in Spiders; or if this does take place, it belongs to a later period.

The yelk does not contain any vitelligenous bodies; but in a great many cases, where the yelk was beginning to darken, I observed in it an irregular, yellowish, granular patch. This patch was too irregular and amorphous to be of much functional importance, and at the same time so generally present, that it could not, I think, be altogether without significance. The patch is of a more or less oval form, and smaller than the Purkinjean vesicle, though somewhat larger than the macula; it is not present in very small eggs, nor in those which have become quite opake. I am inclined to look upon it as corresponding with the concentrically laminated body found in similar stages of the egg in some spiders; at the same time, I desire rather to throw this out as a hint than to express it as an opinion.

Acetic acid slightly darkened the yelk, and made the patch almost invisible.

Polydesmus (Plate XVI. figs. 4, 5, 6, 7).—In form and arrangement the generative organs, both male and female, in this genus resemble those of *Iulus*. The development

of the young ovules, however, is by no means the same. They do indeed form two distinct series, as is the case in all Chilognaths; but instead of eggs in all stages lying indiscriminately next to one another, and without the least arrangement, we here find all the youngest eggs occupying the inner border of the series; and as we pass across the series from the median line of the body to the sides, we pass from the youngest to the oldest eggs. Moreover each line of eggs is in approximately the same stage of growth; so that all the eggs in the outer row and all the inner row are respectively of nearly equal size, and those constituting the intermediate rows are of intermediate dimensions. The smallest eggs which I could see well were rather less than $\frac{1}{1000}$th of an inch in diameter, and quite transparent. They did not seem to be enclosed in any distinct follicle, although in later stages, when they had increased to $\frac{1}{200}$th of an inch in diameter, an epithelial membrane with distinct nuclei could be seen as distinctly as in *Iulus*. In the very young eggs, however, I could never see a trace of it; yet their margin was so clear and well marked, that it was difficult not to believe that each egg was formed by a true cell. Moreover, under the action of dilute spirits of wine the yelk darkened, and often contracted irregularly, in which case the margin of the egg remained as before, and was perfectly distinct.

We have here almost the same difficulty as in the question about the skin of certain Infusoria; but the point is perhaps of more importance, since if we regard each egg in *Polydesmus* as a specially modified cell, we could no longer consider it as homologous with the egg of certain other Myriapods, as, particularly, of *Glomeris*. I have, however, never met with any stage intermediate between the youngest eggs and the true epithelial cells, and cannot, therefore, at present solve the question.

In very young eggs the Purkinjean vesicle scarcely seems to possess any definite membrane; and sometimes, even in eggs as much as $\frac{1}{300}$th of an inch in diameter, on the addition of pure water its outline became flocculent, and finally disappeared. Different eggs, however, behave very differently in this respect. In Plate XVI. fig. 8, I have represented three eggs as they appeared at the same time in the field of view. They were dissected out in sugar and water, and then put into pure water. One (*a*) has remained unaltered, except that the macula has become, as usual, darker; in the second (*b*) the Purkinjean vesicle has disappeared and the macula remains; in the third (*c*) the macula has disappeared and the Purkinjean vesicle remains.

I did not see in *Polydesmus* anything equivalent to the "patch" which occurs in the young eggs of *Iulus*. In the smallest eggs the macula was already very distinct. In a few cases it seemed to contain one or more nucleoli, but generally it gave me the impression of being a more or less solid body attached to the wall of the Purkinjean vesicle. At first the Purkinjean vesicle was $\frac{1}{2000}$th or $\frac{1}{2250}$th of an inch in diameter, or about half as large as the egg; when, however, the egg has increased to $\frac{1}{250}$th, the Purkinjean vesicle has only increased to about $\frac{1}{1000}$th. At this stage the yelk-granules commence to be formed in the egg; they are at first very small, and give it a brownish appearance.

The macula increases in size nearly in proportion to the growth of the Purkinjean vesicle, and is single from the earliest stage observed up to the latest, but appears often to contain vacuola.

In eggs $\frac{1}{180}$th of an inch in diameter the Purkinjean vesicle is almost hidden by the dark opake yelk, whose globules are about $\frac{1}{8000}$th of an inch in diameter. At this stage it scarcely differs, except in size, from its appearance when it first became visible.

After this the egg increases but little in diameter; the yelk-globules, however, grow until they become about $\frac{3}{8000}$ths or $\frac{4}{8000}$ths of an inch in diameter, and the egg becomes quite opake. At this stage I could, on applying pressure, see a clear space, which was probably the Purkinjean vesicle; but it was so delicate, and the yelk-substance was so viscid, that I was never able to get a good view of it. Acetic acid darkened the yelk but slightly, and did not bring any vitelligenous bodies into view. It dissolves the Purkinjean vesicle and macula, as usual. Ammonia makes the whole ovary very pale, the macula invisible. It also causes the Purkinjean vesicle to disappear, but not so quickly. The epithelial nuclei are, if the ammonia is very dilute, rendered plainer than they were before. In mature eggs the yelk consists of at least three parts.

1st. Yelk-globules from $\frac{5}{8000}$ths to $\frac{8}{8000}$ths of an inch in diameter, quite clear and transparent.

2ndly. Yelk-spherules from $\frac{1}{5000}$th to $\frac{2}{5000}$ths of an inch in diameter, and of a greenish hue. These are not so regularly round as the preceding, and have a look of solidity, while under pressure the globules quite lose their shape and run into one another.

3rdly. A viscid substance in which the two first are imbedded.

The spherules and globules are generally of the size indicated, but a good many depart considerably from the average. No trace of a Purkinjean vesicle was ever seen in the mature eggs. These are nearly spherical; and when a number of them are contained in the body, it is difficult to make an incision without some of them coming immediately through it. This was the case with several females which I examined in the middle of August, and in one of which I found 400 ripe eggs, besides which there were a few which I did not count, and a great number in the ovary in all the previous stages. I presume therefore that at this period the walls of the ovary are exceedingly distended, and give way directly they are touched by any sharp instrument.

The female makes a little hollow ball of earth in which she deposits a number of eggs together. I found several of these in the glasses in which I kept these animals, while on the contrary the specimens kept in confinement by M. Fabre *, did not lay any. I unfortunately omitted to isolate these eggs, or to watch for the moment of their hatching, and cannot, therefore, state in what form the young one leaves the egg. A few days after the eggs had been laid, however, I found a number of young Polydesmi

* *Loc. cit.* p. 274.

in my glass, and they consisted of eight segments, including the head; they had three pairs of legs, which were attached to the second, fourth, and fifth segments, leaving the first, third, sixth, seventh, and eighth without feet.

By the month of October most of the females had laid their eggs. The ovary then contains another set, the largest of which were, in four specimens examined by me, just beginning to become dark. These do not appear to be laid until the following spring; at least this was the case with some specimens which I kept in confinement.

The spermatozoa much resemble those of *Phalangium*. They are small, elliptical bodies about $\frac{1}{8000}$th of an inch in length, and containing a bright, rod-like nucleus. STEIN appears to be the only naturalist who has hitherto described them from personal observation. He, however, figures them as round cells, with a tendency to arrange themselves in straight lines. I, on the contrary, generally found large quantities heaped together in the testicular sacs, and in the vasa deferentia masses of spermatozoa not unlike those found in *Chelifer*. Neither in *Polydesmus* nor in *Glomeris* does STEIN either mention or figure the nucleus in the elliptic or fusiform seminal cells. M. FABRE says, "Chez le *Polydesmus complanatus* je n'ai trouvé que de menus corpuscules anguleux, sans forme déterminée, réunis plusieurs ensemble en petites pelotes mamelonnées"; I also have constantly found these small masses of angular bodies in the tubular parts of the male generative organs, but not in the lateral sacs. They do not, however, appear to have any relation to the spermatozoa, and seem rather like a product of excretion.

CHILOPODS.

Lithobius (Plate XVI. figs. 8–13).—In the genus *Lithobius* I have examined three species—*L. variegatus*, *L. pilicornis*, and *L. Sloanei.*

The vulva is, as probably in all the Chilopods, situated at the posterior part of the body; and the ovary is in the form of an elongated sac, which extends for a longer or shorter distance towards the head. Besides having the orifice at the posterior instead of the anterior end of the body, the female generative organs of the Chilopods differ from those of the Chilognaths in the important fact, that the ovary lies *above* instead of *below* the intestine.

The eggs arise singly, each in a separate follicle, and, as I have already mentioned to be the case in Chilognaths, project *into* the general cavity of the ovary, instead of from its external surface. They occur in the same individual in all stages, and without any regularity, the largest and smallest lying side by side in the most complete confusion. The ovarian wall consists, as usual, of an outer structureless membrane, while the small epithelial cells are confined to the single stroma and the ovarian follicles.

The smallest Purkinjean vesicles which I met with were rather less than $\frac{1}{1500}$th of an inch in diameter. I did not see any cells intermediate in character between the ordinary epithelial cells and the smallest Purkinjean vesicles, but I am inclined to think that the latter are modifications of the former. The macula was distinct, and apparently consisted of several small rounded bodies more or less closely attached to one another.

The cells constituting the wall of the follicles are transparent, and vary in size from $\frac{3}{8000}$ths to $\frac{6}{8000}$ths of an inch in diameter. Their nuclei are distinct, and from $\frac{2}{8000}$ths to $\frac{3}{8000}$ths of an inch in size. Sometimes the cells are almost invisible, and the nuclei only can be seen.

In eggs rather more advanced, a certain quantity of clear yelk may be seen round the Purkinjean vesicle, and the macula consists of about seven bright, solid-looking bodies, each measuring about $\frac{1}{3500}$th of an inch in diameter. The diameter of the Purkinjean vesicle is at first about half as large as that of the follicle in which it is contained, but increases in size much more slowly than the latter. When the follicle is about $\frac{1}{200}$th of an inch in diameter, the yelk begins to become dark from the deposition of granules, which are very minute, none exceeding $\frac{1}{8000}$th of an inch in size. In the mean time the maculæ have become smaller and more numerous, until in the largest Purkinjean vesicles there are a great many of them, and they are very minute.

This gradual increase in the number and diminution in the size of the maculæ occurred in all but one of the specimens examined by me. In this case many eggs, even among those which had begun to darken, contained a large macula, generally surrounded by smaller ones.

A great many of the eggs contained a vesicle (Plate XVI. figs. 11, 12, &c.) like that of *Arthronomalus*, but much smaller and with no distinct nuclei. This small vesicle could by no means always be seen; and even in those ovaries in which it was most distinctly visible, it appeared to be present only for a short time. It seemed to be succeeded by a small patch, like that already described as occurring in *Iulus*. It is not seen in eggs less than $\frac{1}{100}$th of an inch in diameter, and it can no longer be distinguished when the yelk has become quite opake. In one specimen out of twenty-six egg-follicles, larger than the above size and yet not opake, I saw it in eighteen, but in other specimens it was less constant, or even perhaps altogether absent. I have several times been inclined to look upon it as a mere accidental agglomeration of yelk; but it is, I think, too regular and too constantly present. All that I have said about the "patch" in *Iulus*, applies equally well to that of *Lithobius*.

When the egg has attained a size of $\frac{1}{100}$th to $\frac{1}{63}$rd of an inch, it has become quite opake, and without compression its contents cannot be distinguished. The yelk consists of oil ?-globules, varying from $\frac{1}{2000}$th of an inch down to a very minute size, and imbedded in a clear, sticky substance. On applying pressure the germinal vesicle at once comes into sight. It is $\frac{10}{2000}$ths of an inch in diameter, and shows no trace of any nucleus, but appears to contain a clear fluid, with minute granules.

At this stage the yelk seems to be surrounded by a delicate membrane, which, when the egg is mature, has become a strong shell. In eggs of this size it often happened that on applying pressure a second clear space appeared, always detached from, and three or four times as large as, the Purkinjean vesicle. This appeared to be a portion of the yelk free from the globules and granules; it had no definite outline, and gene-

rally, after the egg was crushed, could no longer be perceived; once, however, I succeeded in isolating it from the yelk, when it took the form of several clear masses apparently of a glairy substance, without any membrane, though with a clearly defined border. In this case the Purkinjean vesicle contained a number of small cellular bodies, about $\frac{1}{8000}$th of an inch in diameter, and exceedingly like the embryo-cells of *Coccus**, having the same greenish tinge and somewhat angular outline. The yelk-masses, which were at first transparent, turned an opake yellow under the action of water; but the process was much slower in some than in others. Acetic acid only slightly darkened the eggs, and did not bring any vitelligenous cells into view. It completely wiped out the macula. Under ammonia the young follicles became very faint, and the Purkinjean vesicle disappeared.

The largest eggs in which I found Purkinjean vesicles were from $\frac{25}{2000}$ths to $\frac{32}{2000}$ths of an inch in diameter, the vesicle being about one-third of that size.

The mature eggs from the cavity of the ovary were about $\frac{7}{200}$ths in diameter, and nearly spherical in shape. They contained the usual yelk-masses, of which the larger ones were $\frac{5}{8000}$ths of an inch in diameter, and under pressure split at the sides like those of *Iulus*. They contained no Purkinjean vesicle.

I was for some time much puzzled by finding among the ordinary eggs certain spindle-shaped bodies, some of which were very narrow, while others were so broad as scarcely to differ from the spherical eggs, except by having one side flattened. They were surrounded by a layer of epithelial cells, contained ordinary yelk, with generally a Purkinjean vesicle, and in fact possessed all the characteristics of true eggs. For some time I believed that, besides the spherical eggs, other more or less spindle-shaped ones were produced in the ovary of *Lithobius*, so that, as in *Daphnia*, the same ovary gave rise to two sorts of reproductive bodies. At length, however, it occurred to me to cut off part of a young egg; and I then at once found that the larger portion of the wounded egg was one of my spindle-shaped bodies, which therefore were nothing more nor less than the ova which had been accidentally cut through in the dissection of the ovary. If, however, the eggs are too large, they simply burst when cut, and the contents escape. The most suitable ones are those which contain granules and have not yet developed any large oil-globules. This observation would be scarcely worth mentioning, were it not that the cut surface of the yelk presents an outline which is as well defined as the other parts, and shows no trace of the wound. It is of course evident that this part cannot be surrounded by any membrane, and the similar appearance presented by the rest of the yelk is therefore deceptive. So definite or clear, however, is the outline, that it is difficult not to believe in the presence of a vitelline membrane, and it seems probable that the membrane described as surrounding the egg-germs of some other animals may have its origin in a similar deception.

The numbers of the two sexes seem to be nearly the same: thus out of thirteen speci-

* Philosophical Transactions, *loc. cit.* p. 364.

mens of *Lithobius pilicornis* seven were males; in *L. forficatus* the only two specimens examined were males; and out of three specimens of *L. variegatus* two were females, making altogether ten males to eight females.

The number of labial teeth is used by NEWPORT as a specific character; but I found in this respect an astonishing want of symmetry: thus, in the few specimens examined by me, a male *L. variegatus** had seven labial teeth on one side and nine on the other; three specimens of *L. pilicornis* had six teeth on one side and only five on the other, while two others had only four teeth on one side; making altogether, out of twenty-eight specimens, nine which were abnormal in this respect.

In addition to the Gregarinas, which are very generally found in the Myriapods, and particularly in *Polydesmus* and *Glomeris*, I have met with a few other parasites. A specimen of *Lithobius pilicornis* contained, not in the intestinal canal, but in the general cavity of the body, two Nematoid worms 3 inches in length. Two other specimens of the same species contained respectively one or two dipterous larvæ.

Cryptops (Plate XVI. figs. 19, 20, 21).—In this genus the ovary is narrow, and its walls are very delicate. The eggs are not arranged with any regularity as to size. They are at first round, but soon become elongated, with their longer axis parallel to that of the ovary, and do not appear to be so numerous as in *Lithobius*. As in most other genera of Myriapods, the macula is single at first; but in this genus, as in *Glomeris*, a secondary smaller macula may in subsequent stages almost invariably be found in the Purkinjean vesicle. It is remarkable that this genus should differ so entirely from *Lithobius* in the history of its macula. The formation of the eggs in other respects is, however, very similar in these two genera. The epithelial nuclei on the egg-follicles could in some cases be very plainly seen; but the ovary did not contain any loose nuclei or cells, except those which had already become young eggs. These latter seem to come to maturity late in the autumn. A female examined in the middle of September contained no ripe eggs; indeed the largest ones were only $\frac{1}{400}$th of an inch in length, and the yelk had only just begun to darken.

Another female, examined on the 24th of October, was more advanced; and a few of the eggs were opake, though none were yet quite ready to be laid.

Acetic acid darkened the yelk but slightly, and brought no vitelligenous bodies into view. It dissolved the macula as usual.

In all the specimens examined by me, the spermathecæ were full, but contained filiform spermatozoa *only*, without any of the ovoid cells which accompany the spermatozoa in the spermatophores. These spermatophores were, I believe, first observed by M. FABRE, and I could add little to the excellent description of them given by him. He does not, however, mention in the text†, although he has represented in his figure, certain small elliptic bodies which are found in the spermatophores with the filiform

* Another specimen, of which the sex was not determined, had only six teeth on one side; and two others had eight on one side and seven on the other.

† Unless under the name of the "pulviscule blanche," which forms a layer round the spermatozoa.

spermatozoa. These bodies are probably analogous to the vesicles which in the spermatic sacs of some Entomostraca surround the filiform spermatozoa; and the function which is ascribed to the latter, namely, that of imbibing moisture and so expelling the filiform spermatozoa, may also perhaps belong to the former. Nevertheless one cannot but be struck with the fact, that they exactly resemble in shape the elliptic bodies which are found in the testis and spermatheca of *Chelifer*, and which cannot have any such function. In the present species, however, as above mentioned, the elliptic vesicles do not appear to find their way into the spermathecæ.

M. FABRE, to whose excellent paper I have already so often alluded, made, with reference to some Chilopods, the very curious observation that the male spins a sort of nest, or rather web of silk, and deposits in the middle a drop of semen. He has not actually observed that the genus *Cryptops* has this extraordinary habit, but he thinks it probable. From the fact that the two spermathecæ of the female *Cryptops* generally contain spermatozoa, it would seem that the females must have the scarcely less remarkable instinct to visit these nests, and in some manner absorb the contents into their vagina.

I find much difficulty in imagining how, under Mr. DARWIN'S theory, such habits as these can have originated. It is easy enough to understand how they can continue when they have once existed long enough to harden into an instinct; but I do not understand how they can have begun. It may be hoped, however, that we shall find among other Myriapods some species with less abnormal habits, or that in some other manner new light may be thrown on the matter.

GEOPHILIDÆ.

*Arthronomalus** (Plate XVI. figs. 16, 17, 18).—In this genus the form of the ovary resembles that of *Cryptops*; the eggs, however, are less elongated. The smallest egg-germs were about $\frac{1}{1000}$th of an inch in diameter, and consisted of a macula, which was often double, a Purkinjean vesicle, and *apparently* a vitelline membrane. In all probability, however, no such membrane is present.

It seemed to me also that in *Arthronomalus* the young egg-germs were not enclosed in any separate follicle, though on the larger eggs the usual epithelial layer could be seen. The macula in eggs a little more advanced was, as far as my observations went, never multiple, and resembled therefore in this point *Cryptops* rather than *Lithobius*.

In the eggs of *Arthronomalus* the vitelline vesicle is particularly distinct; it cannot, however, be perceived until about the period when the yelk begins to become opake; at this stage, however, it makes its appearance, and almost always contains a few globules. Indeed, when only a few yelk-globules are present, they generally all lie in the vitelline vesicle. Plate XVI. fig. 17 represents an egg with a Purkinjean vesicle and spot, and at *a* this curious body, which I may perhaps call the vitelline vesicle. I cannot term

* I examined some specimens of *A. longicornis*, and also some which had the antennæ nearer together, with about sixty-eight pairs of legs..

it a cell, first, because I could not satisfy myself that it had a distinct membrane; and secondly, because it is doubtful whether it is homologous with the true vitelligenous cells of insects,—these latter being coeval with the Purkinjean vesicle, while I never saw the vitelligenous vesicle of *Arthronomalus* except in eggs which were already of some size, and in which the yelk was beginning to become opake. We must, I think, seek for its analogue rather in the yelk-nucleus described first by WITTICH in the eggs of spiders.

*Geophilus** (Plate XVI. figs. 22–26).—In the form of the ovary and the first stages in the development of the eggs, this genus much resembles *Arthronomalus*. At the end of November, the long, narrow ovary contained a single series of about thirty or forty nearly mature eggs, which could even be perceived through the skin. Around them were others in earlier stages of development; but there was a considerable interval between the most advanced of these and the large ones, which latter were approximately equal in size, and are probably all laid together.

In the young eggs the Purkinjean vesicle resembled that of *Arthronomalus*, and the macula was single, sometimes apparently homogeneous, sometimes nucleated, or, rather, perhaps vacuolated. In the smallest eggs the Purkinjean vesicle was round, but in others a little more advanced it exhibited one or two prolongations. What, however, struck me as very interesting was that the Purkinjean vesicles in several specimens, in which the eggs were rather larger, were no longer homogeneous, but appeared to consist of two substances, one surrounding the other (Plate XVI. figs. 22–26). The inner portion was generally produced at one or two places; and as the boundary of the outer part was less affected or even quite circular, the inner part passed at these places almost or quite through the outer substance. In some cases the macula also appeared to have undergone subdivision. It appeared to me that portions of the Purkinjean vesicle in this manner gradually separated themselves from the rest. At any rate many of the eggs, at the stage when the yelk was beginning to become dark and granular, contained one, two, or three patches, which were apparently detached portions of the Purkinjean vesicle.

I naturally referred with much interest to the vitelline vesicle of *Arthronomalus*; but in this genus the Purkinjean vesicle is always circular and homogeneous. If, therefore, the homogeneous yelk-masses of *Geophilus*† do originate in the manner indicated, it would appear that they are not homologous with the vitelline vesicle of *Arthronomalus*, which does not seem to be derived from the Purkinjean vesicle. It is, however, very improbable that two genera in other respects so nearly allied, should differ in a point

* I examined *G. acuminatus*, and also some specimens which had about fifty-three pairs of legs, filiform antennæ, and the basilar segment smaller than the sub-basilar. I am inclined to think from these characters that they must belong to *G. brevipes*, of which NEWPORT had only seen a single specimen.

† A somewhat similar though apparently more regular subdivision of the Purkinjean vesicle has been figured by LEUCKART (Unter. z. Nat. des Mens. und d. Thiere, 1858) as occurring in *Aphis*. LEUCKART also mentions a vitelline vesicle as existing in *Geophilus*; but his species probably belonged to the nearly allied genus *Arthronomalus*.

apparently of so much importance; and in all probability, therefore, a true vitelline vesicle will be discovered in *Geophilus*, though it is certainly not so conspicuous as in *Arthronomalus*. Certainly no such vesicle has yet been noticed in *Cryptops*, but it may perhaps have been overlooked in that genus also.

In the largest eggs the yelk completely hid the Purkinjean vesicle, which, however, became evident on the application of pressure. It had become again homogeneous and round, and was about $\frac{1}{200}$th of an inch in diameter. The macula was single, but often vacuolated.

Acetic acid darkened the yelk and destroyed the macula, as usual. The Purkinjean vesicle remained visible by contrast of shade. The full-grown eggs were about $\frac{6}{200}$ths of an inch in diameter; and the yelk consisted principally of small oil-globules, not larger than $\frac{1}{2000}$th of an inch.

ARACHNIDA.

PHALANGIDÆ.

Nemastoma bimaculatum, FAB.—This pretty little species is common in Kent, under stones, logs of wood, &c. When found, it often feigns death; and its horny skin and dark shrivelled appearance may well deceive any unsuspicious observer. It is altogether black, excepting two white patches on the back; and as no other English species is at all like it, it has for the physiologist the great merit of being easily identified.

The general arrangement of the female generative organs is much like that of *Phalangium Opilio*, as described by TREVIRANUS* and TULK†. A female dissected in the middle of September already contained a few mature eggs, but these became much more numerous later in the autumn.

The external membrane of the ovary is, as usual, structureless; but on one or two of the follicles in an allied species, *Phalangium cornutum*, I saw bright spots, arranged at tolerably regular intervals, and raised a little from the general surface. These were probably the last remnants of nuclei, which had disappeared altogether everywhere else. The membrane is in places thrown into numerous follicles. Inside the outer membrane I found no regular layer of epithelial cells, but a number of nuclei apparently imbedded in a homogeneous substance. These nuclei (if I may call them so) are in this species unusually plain, round, or elliptical in shape, from $\frac{1}{2000}$th of an inch to $\frac{1}{1000}$th of an inch in length, and with finely granular contents. One of the granules is generally larger than the rest, and thus represents a nucleolus.

It seemed to me that the origin of the egg was as follows. The nucleolus of one of the larger nuclei, lying next to the external membrane of the ovary, increased in size, while the other granules disappeared; and the nucleus having gradually become a Purkinjean vesicle, and passed into a follicle, we have thus all the elements of a young egg-germ. Whether, however, all the ovarian nuclei are thus in turn developed, or whether, as I have sometimes been inclined to think, some of them, after attaining to

* Vermischte Schriften, p. 34.

† Annals and Mag. of Nat. Hist. 1843.

the maximum size, become merely vitelligenous bodies, and not true Purkinjean vesicles, I could not satisfactorily ascertain. If even, however, this is the case, the yelk-forming nuclei do not themselves enter the follicle.

It results from the above description that the ovarian capsules consist of a simple membrane, and are not bounded, as in insects and Myriapods, by any inner layer of epithelial cells. The smallest Purkinjean vesicles observed were about $\frac{1}{1330}$th of an inch in diameter, and had a single solid-looking macula. At this period the Purkinjean vesicle and the yelk are quite clear and transparent; nor are they darkened by the action of dilute acetic acid, though the former is, as usual, destroyed by it.

When, however, the egg-follicle is about $\frac{1}{200}$th of an inch in diameter, the yelk begins to become granular, and in consequence darker in colour. The granules are at first quite small, but they rapidly increase in number; and when the egg is $\frac{3}{200}$ths of an inch in size it has become quite opake.

During all this period the Purkinjean vesicle remained unaltered, except in size. The macula also enlarges, and becomes vacuolated; but I never saw it break up, nor was I able to determine its ultimate destination. In an egg $\frac{3}{200}$ths of an inch in length, the Purkinjean vesicle was as before, the macula single and vacuolated.

No trace of either Purkinjean vesicle or macula could I ever detect in the full-grown egg from the matrix. These eggs were of an elliptic shape, $\frac{55}{2000}$ths of an inch in length, by about $\frac{45}{2000}$ths in breadth. The yelk consisted, 1st, of minute, round, greenish globules about $\frac{1}{10000}$th of an inch in diameter; 2ndly, of the usual transparent, somewhat viscid substance; 3rdly, of irregularly-shaped, solid-looking yelk-masses, about $\frac{1}{800}$th of an inch in diameter, and each generally appearing to contain a rounded globule in its interior.

The chorion is a single, simple, transparent, structureless membrane.

The other species of Phalangidæ which I have dissected are *Phalangium cornutum*, *Leiobunus rotundus*, and *Opilio agrestis*, all of which, in the arrangement of their generative organs, agreed in all essential particulars with the preceding species.

In *Leiobunus rotundus* the ovarian nuclei were as distinct as in *Nemastoma bimaculatum*, but rather smaller; in *P. cornutum* they are more delicate, and the contents are less granular. The formation of the egg, of the Purkinjean vesicle, and of the macula proceed almost exactly as in the preceding species, and need not therefore be again detailed. In *L. rotundus*, however, the macula has not the appearance of a vesicle, but rather of a cloud of small granules compacted together.

In some cases the ovary presents a rather unusual appearance, from the fact that the stalks of the ovarian follicles are not circular, but elliptic; this peculiarity struck me more particularly in *Leiobunus*.

The eggs of *P. cornutum* begin to darken when they are about $\frac{10}{2000}$ths of an inch in diameter; and the yelk then consists of very fine particles, not more than $\frac{1}{20000}$th of an inch in diameter.

In *P. cornutum* the egg had become quite opake when it was about $\frac{25}{2000}$ths of an

inch in diameter. At this stage some of the larger yelk-globules were $\frac{1}{4000}$th of an inch in size, but the majority were much smaller. The Purkinjean vesicle was $\frac{10}{2000}$ths of an inch in size, and the macula was, as usual, single; it did not, however, appear to be a vesicle, but rather, as in *Leiobunus*, a cloud of particles, without any true surrounding membrane, and more or less compactly arranged.

The chorion of the egg is no doubt, in all the Phalangidæ, formed by the consolidation of the outer layer of the viscid part of the yelk; and as this process is gradual, it is impossible to say exactly when it begins, or when it is finished. The yelk in the mature eggs of *Leiobunus* and *Phalangium* is constituted like that of *Nemastoma*.

Leuckart says that in *Phalangium*, besides the eggs with a simple, homogeneous macula, there are some in which it is granular, and others in all intermediate stages. I have myself observed the same thing not only in the Phalangidæ, but also in many other Articulata. The difference arises, however, I believe, from the action of the fluid in which the eggs are examined; and the homogeneous specimens represent the normal condition.

The internal male generative organs of *Phalangium* (Plate XVII. fig. 45) have been quite misunderstood, I think, by every one who has written on the subject. Treviranus* described the numerous short white tubes which fall into the vas deferens as "Saamengefässe;" Tulk also says†, "The testes are formed by a cluster of elongated, narrow and slightly tortuous cæcal tubes;" and this view has been generally adopted‡. Each of these tubes contains a narrow central tube, which gives off on each side numerous branchlets; and these branchlets terminate in cluster-like glands. If, therefore, they were simplified and shortened very much, they would resemble in structure the accessory glands of *Chelifer*, which are certainly not testes. It would of course be unsafe to rely much on this comparison; but I never found any trace of spermatozoa in these tubes, which, on the contrary, contained numerous delicate vesicles about $\frac{1}{800}$th of an inch in diameter, and with finely granular contents; the secretion of these tubes, too, is, I believe, a fluid. On the other hand, among these short tubes I always found one much longer than the rest (Plate XVII. fig. 45, *d*), and convoluted instead of nearly straight. Its internal structure also was entirely different, being without any such small branched duct and glands. This I regarded at first as the true testis, especially as at its lower end it contained immense numbers of minute spherical bodies, which are the spermatozoa.

There is, however, another large tube (*a*), which was already known to Treviranus§, and described by him as the Z-shaped tube. As it occurs only in the males, he presumed that it was connected with the secretion of the semen, but he was unable to trace its connexion with the other generative organs. The tube lies across the digestive organs, and

* Vermischte Schriften, p. 36. † *Loc. cit.* p. 21.

‡ Leuckart, article "Zeugung;" Siebold and Stannius's 'Anatomy;' and Leydig, "Zum feineren Bau der Arthropoden," Müller's Archiv, 1855.

§ Vermischte Schriften, p. 37.

at each end contracts into a fine tubule (*b*), which TREVIRANUS traced a little way among the stomachal cæca and then lost. TULK was scarcely more fortunate. He says of it, "I examined the direction of these minute ducts with great care, and found that they pass forwards and curve round the tracheal trunks, near to their origin, from above downwards, and are lost at the inner extremity of the spiracular groove, where they may probably open externally. The function assigned to this part is thus rendered extremely problematical."

This description much excited my curiosity. A simple tube running transversely across the body, and opening at each side, would be an organ entirely without a parallel among the Articulata, or, so far as I know, in the whole animal kingdom. Moreover, after a little consideration I could not help thinking that this must be the testis, not only because it occurred only in the males, but also because its situation was much like that of the ovary, and because its contents much resembled immature spermatozoa.

The contents of the abdomen are, however, so intricate, and the fine continuations of the tube are so closely attached in places to the tracheæ, and so delicate in themselves, that only after several failures did I succeed, in *Ph. urnigerum* and *Leiobunus rotundus*, in tracing what I may call the vasa deferentia of the testis beyond the tracheal trunks (*c*). At length, however, I succeeded in doing so, and found that they turned round again and passed with many convolutions to the central line of the body, where they fell into the delicate end of the common ductus ejaculatorius (*d*). Thus, therefore, all doubt as to the function of the Z-shaped tube is removed, and we see that the male and female organs of *Phalangium* offer the same parts, and are formed on exactly the same type. In both of them the secretory part, the testis in one sex and the ovary in the female, is in the form of a ring the posterior part of which is much wider than the anterior, while from the centre of the anterior half proceeds a tube which is rather short and very wide in the gravid female, while it is narrower and longer in the male.

Mr. NEWPORT, in his paper on *Iulus*, expresses his admiration at the remarkable similarity existing between the generative organs of the two sexes in that genus. In this case, however, the simplicity is so great that the similarity is much less striking than in *Phalangium*, where both organs are of a most unusual form.

The spermatozoa, as they are found in the ductus ejaculatorius, are minute spherical bodies, about $\frac{1}{6000}$th of an inch in diameter, of a greenish hue, and containing a brightly refractive, rod-like body. Whether, however, this is their definite shape I am unable to say, not having noticed them in the female. LEUCKART, in his justly celebrated article "Zeugung," has given a nearly similar description of these bodies. LEYDIG*, however, has obtained them from the vas deferens, and concludes, rather from noticing that they possess a tremulous motion than from any actual observation, that they are provided with fine cilia. In *P. urnigerum* the accessory tubes were quite short, and much branched.

* *Loc. cit.* p. 469.

In *Opilio agrestis* and *Nemastoma bimaculatum* the male generative organs were formed nearly as in *Phalangium*, but I have not actually traced the connexion between the testis and the ductus ejaculatorius. In *O. agrestis*, however, I traced the latter up to its bifurcation, and the vasa deferentia as far as the great tracheal trunks; so that no doubt in all the Phalangidæ these parts are formed on the same type.

SCORPIONIDÆ.

Chelifer (Plates XVI. and. XVII. figs. 27–36).—Although the testis of *Chelifer* closely resembles that of the Scorpion, the ovary of the two genera is very different. Instead of the net-like complex organ of the Scorpion, we find in the smaller Chelifers only a simple, tubular organ, extending backwards from the vulva and bearing from thirty to fifty eggs in one stage of development, enclosed in spherical follicles on short stalks, and arranged in a row on each side with more or less regularity.

Between these eggs lie others which are not so far advanced, but which, when the first have been laid, will in their turn attain to maturity. Besides these two series of eggs, I generally found other small follicles, with irregular yellowish contents; these are probably follicles from which the eggs have escaped, and their yellowish contents are "corpora lutea," homologous with the yellowish contents so often found in insects at the lower end of the egg-tubes, and which have been compared by STEIN to the "corpora lutea" of the higher animals.

I am not able to throw much light on the early stages of egg-formation; but it seemed evident that in *Chelifer* the egg-follicle was formed by one single simple membrane, the epithelial cells occupying the stalk only. These were so delicate, that without the action of reagents they could scarcely be perceived; but if water, either pure or with a trace of ammonia, be used instead of syrup, they become more evident. Although, however, the follicle is not lined by any epithelium, occasionally one of the cells could be detected in it.

The epithelial cells varied from $\frac{3}{8000}$ths of an inch to $\frac{6}{8000}$ths of an inch in diameter, and had a distinct though pale nucleus. Among them I found other solid-looking bodies, about $\frac{3}{8000}$ths of an inch in diameter. I never succeeded in making out satisfactorily the origin of the Purkinjean vesicle; but, from analogy with what is stated to be the case in Spiders, and with what occurs in other animals, it seems probable that one of the epithelial nuclei increases in size, developes the yelk round itself, and causes the external membrane to bend outwards. The macula appears to be originally simple; it is always, however, a difficult subject for investigation.

In the early stages the yelk possesses a definite outline, but, as the action of a drop of ammonia shows, this does not arise from the presence of any true membrane. It is at first clear and transparent; but when it has attained a size of $\frac{1}{500}$th of an inch, yelk-globules begin to appear in it; and these become more and more numerous, until, when the egg has attained about $\frac{1}{300}$th of an inch, the greater part of it is occupied by them, and the Purkinjean vesicle completely hidden. They are generally somewhat collected

round the centre, so that the margin is still composed of the clear yelk-substance; and their refrangibility is great, so that they give the egg a peculiar and beautiful appearance.

They do not continue to enlarge as they increase in number; but even when only two or three are present, they are often as much as $\frac{1}{2000}$th of an inch in diameter—a size which is seldom exceeded even in full-grown eggs.

The females are provided with a sac, which I think myself justified in calling a spermatheca. It opens close to the vulva, is slightly narrowed at the outlet, cylindrical in form, and more or less bent at the end, which is double. I always found it full of the greenish ovoid spermatozoa. They exactly resembled those found in the testis and ductus ejaculatorius of the male, but sometimes seemed to have developed round themselves a cellular envelope. I never found in this organ any filiform spermatozoa.

Weak acetic acid dissolved the Purkinjean vesicle and macula as usual, but it had no effect on the yelk-globules, nor the intermediate clear yelk-substance. Very dilute *ammonia* also dissolved the macula, and, as above mentioned, at first made the epithelial cells more distinct. It did not affect the yelk-globules, nor darken the yelk-substance, but apparently it caused the latter to swell, since, although the wall of the follicle did not seem to shrink, the contents were more or less completely ejected from it. It had no effect on the yellowish "corpora lutea."

I began to examine *Chelifer* in the month of August; and of the first few specimens collected nearly one-half had eggs or young ones attached to them*. The eggs were seventeen or eighteen in number, and were enclosed in a sort of case, in shape somewhat resembling a D (Plate XVI. fig. 29). Each egg had a more or less separate compartment; and they were arranged in one plane, five being generally in the middle, and the remainder surrounding them in a single series, the straight border containing four or five. The case lay at the lower side of the abdomen, with the straight margin in front, and was attached to the body of the animal at or close to the vulva. The case itself consists of a transparent structureless substance.

I met with five specimens in this condition, but, being busy at the time, and expecting to find others in the autumn, I unfortunately made only a few rough notes. The eggs were about $\frac{13}{2000}$ths of an inch in diameter, and of various shapes. They possessed a firm chorion. They underwent a regular yelk-segmentation, but the yelk-spheres by no means filled the egg. The eggs in each case were in approximately the same stage of development. The most advanced contained eight yelk-spheres† (fig. 28), and also some large, clear, transparent vesicles.

The yelk-spheres occupied about two-thirds of the egg, and appeared to be composed of oil-globules, loosely connected together, and each about $\frac{2}{8000}$ths of an inch in dia-

* De Theis also found a female of *C. cancroides* with eggs attached to the under side of the abdomen. (Ann. Sc. Nat. 1st ser. vol. xxvii.)

† This was the case with all the eggs in three of my specimens, and it is remarkable that Grube never found more than eight spheres of segmentation in the eggs of *Clepsine*.

meter. I only met with one specimen carrying young. The latter were fully developed, and of the mature form, but still incapable of motion. They were much larger than the eggs.

On dissecting these five specimens I was astonished to find in them no trace of an ovary, nor of a testis, but instead, and in the same position, I found a large organ (Plate XVII. fig. 30) consisting of thirty short cylindrical cæca with parallel walls. In front the organ passes into two large bags; and from the anterior end of each of these, rises a short duct. I did not trace these ducts to their extremity; but they probably open near to one another. This seemed to happen close to, if not at the place, where the vulva occurs in ordinary specimens. The organ contains oil-like vesicles, which vary in size up to $\frac{10}{8000}$ths of an inch; the usual size, however, is from $\frac{2}{8000}$ths to $\frac{3}{8000}$ths of an inch, and the larger ones contain daughter vesicles. It would appear that this remarkable organ must secrete nourishment for the embryos, in which way we may account for their great increase in size before leaving the mother. I have not, indeed, evidence sufficient to prove this; but it would not be altogether without analogy, since LEUCKART has discovered in the viviparous Diptera a branched organ which secretes a substance to serve as food for the young during its stay in the uterus.

Whereas, however, this branched organ is present in all the females of the viviparous Diptera, I have never found the sacculated organ of *Chelifer* except in the egg-bearing specimens, although in the months of September, October, and November I dissected a great many females, and particularly sought to find the structure in question.

All the specimens examined by me were found within a few feet of one another, under some planks which were lying on a hot-bed in our kitchen-garden, and I noticed no external difference between the egg-bearing specimens with the sacculated organ and the ordinary males and females. Unfortunately, however, my attention was not at first directed to this point; and when after only a fortnight's interval I returned to my Chelifers, no more case-bearing specimens were to be found, though in the last fortnight of September I looked over more than a hundred specimens in hopes of finding some. Moreover, the females examined during this time and up to the beginning of November, all contained eggs developing in the ovary, as above described. It is also worthy of notice that, whereas the ovary always contained from thirty-five to forty eggs in one stage of development, the number of eggs in each egg-case was only seventeen or eighteen, as before mentioned.

It may naturally be asked to what organ in the ordinary females this sacculated structure corresponds; and to this question I can give no satisfactory answer. It seems most probable, however, that it is a modification of the ovary. The form and position of these two organs is very similar; and there are two ducts, as in the testis; moreover, the egg-follicles of the one are somewhat similar in size and shape, and not very different in number, from the cæca of the sacculated organ. In one instance also I found the ovarian follicles with numerous small greenish oil-globules, while in the regular course of egg-development they contain large, dark, and very bright ones. In this state the ovary

much reminded me of the sacculated organ, and had all the appearance of being in an intermediate condition.

I am only too well aware that my observations have not yet gone far enough to justify any definite conclusions, but they seem to indicate that the eggs of *Chelifer** are in summer carried about by the animal, that the young ones in this position grow to some size, being nourished by a milky fluid secreted for that purpose by a special organ, but that, when winter comes on, the eggs are laid by the mother in some secure place, and perhaps do not hatch until the warm days of spring. Furthermore, the fact that each female *Chelifer* produces thirty-five to forty eggs in a brood, while the egg-bearing specimens have only seventeen or eighteen eggs attached to them, and that while these specimens, which I may perhaps be permitted to call "nurses" (though in a natural, and not a Steenstruppian sense), have the absent or at least rudimentary ovary† or testis, the ordinary specimens do not possess the peculiar sacculated "milk-gland," would seem to indicate (though I dare not do more than suggest the possibility) that in *Chelifer*, as in so many Hymenoptera, we have, besides the males and females, certain so-called neuter specimens which are (probably in this case also) females with imperfect generative organs, and whose function it is less to lay eggs themselves, than to feed and tend the young ones produced by the perfect females.

In September the males of *Chelifer* seem to be about as numerous as the females; out of the last sixteen specimens which I examined, eight were males, and eight were females.

The generative organs open at the anterior end of the abdomen. At the orifice is a peculiar chitinous body, broader at both ends than in the middle, and provided with strong muscles.

On one side of this body are two large vesicular organs (Plate XVII. fig. 36), each in the form of a sphere, with a deep transverse medial constriction. The free half is pale, delicate, and apparently empty; the other has a thicker wall; it contains about twenty-five straight, narrow canals of unequal length, and at the free end of each is a crown or flower of glandular bodies, which probably pour their secretion into the straight canal.

The testis (Plate XVII. fig. 31, *a*), which probably lies between the sternum and the digestive organs, is single, and consists of a median and two lateral tubes, united by three transverse branches. It represents, therefore, in miniature that of the Scorpion, differing from it, however, in that the two testes have coalesced along the middle line. This was, at least, the structure of the testis in six males which I dissected; in the first one, however, I thought I found four transverse branches; but as no second instance of this presented itself, the drawing I made at the time may be incorrect.

The vas deferens (*b*) is double, and about as long as the testis. I did not ascertain the exact relation which they bear to the orifice; but at the base of the above-mentioned chitinous body each of them forms a spherical swelling, and on leaving the testis one of them always formed a second elliptic sac. In most of the cases examined by me this

* The egg-bearing specimen noticed by De Theis was found in June.

† Or perhaps only a rudiment of one.

chamber occurred only in one of the tubes, and the other one was of nearly equal diameter from the testis to the anterior spherical chamber. In one, however, two sides were symmetrical, as I have represented in Plate XVII. fig. 31, *b*.

The spermatozoa are apparently produced indiscriminately in all parts of the testis. They are of an oval form, and are found in rounded masses (Plate XVII. fig. 32). I also found in some specimens cells containing filiform spermatozoa; but later in the autumn only the oval bodies were present. They are perhaps immature forms; but against this view must be set the fact that the spermatheca of the female contained these bodies only. It is, however, very unlikely that they should be altogether different from the spermatozoa of the so nearly allied genus *Obisium*.

The *tracheæ* open through orifices at the sides of the second and third abdominal segments; the spiracles lead into a short thick tube, from the end of which arise a great number of long thin tracheæ, which pass, without giving off many branches, to the different internal organs.

Obisium.—I found, under a piece of wood, in September and October last, five specimens of *Obisium muscorum*, only one of which was a female. It was caught on the 16th of October, and had no case of eggs, but the ovary contained eggs in course of development; and much resembled that of *Chelifer*. The egg-follicles contained sufficient oil-globules to hide the Purkinjean vesicle, though it became visible on the application of pressure. The oil-globules were rather even in size, and much smaller than in *Chelifer*, not exceeding $\frac{1}{8000}$th of an inch in diameter.

The testis resembles in form that of *Chelifer*; but the spermatozoa are very dissimilar. Scattered about in the testis were rounded masses of small cells, which gradually modified themselves into spermatozoa. These masses probably arose by the endogenous multiplication of small cells within a larger one. The rounded masses were of different shapes and sizes, and the development of the spermatozoa seemed to be quite independent of the size of the mass. The mature spermatozoa had a bright cylindrical head, about $\frac{1}{2000}$th of an inch in length and very narrow, and a very delicate, scarcely perceptible tail (Plate XVII. figs. 33 *a*, 35). They were quite motionless. The testis also contained some oval bodies, resembling in shape those found in *Chelifer*; their wall was not, however, so distinct, and I did not satisfy myself that they were not merely detached specimens of the usual small cells. In one specimen I found a number of vesicles of different sizes, and containing small rod-like bodies (Plate XVII. fig. 34). It is possible, however, that in this case I may have had before me some nearly allied species. The complemental glands are lobulated, and not spherical as in *Chelifer*. Each of the tubules, also, instead of ending in a crown of glands, terminates in a single, dark, club- or egg-shaped mass.

Of *O. orthodactylum* I found eleven specimens on the under side of the log of wood which supplied me also with *O. muscorum*. Six of them were males; the form of the testis was like that of the preceding species, but I am not able to speak positively as to the spermatozoa. The development of the eggs appeared to be much like that in

O. muscorum, and the oil-globules were small. None of the females bore egg-cases; but it was perhaps too late in the season.

THYSANOURA.

Petrobius maritimus.—In this interesting animal each of the ovaries consists of a tube running along the side of the abdomen, and giving off, on its inner side, seven short egg-tubes, which lie above the intestine. These latter, therefore, are fourteen in number; and in the beginning of September, when I examined them, each tube generally contained towards its lower end three egg-germs, in which a considerable deposition of yelk had taken place, and towards its free extremity from fifteen to twenty egg-germs in earlier stages of formation.

The egg-tube is lined with epithelial cells, generally from $\frac{1}{700}$th to $\frac{1}{1000}$th of an inch in diameter. Their nuclei are about $\frac{1}{2500}$th of an inch in diameter, and very faint. Often, indeed, they can scarcely be perceived; but, generally, when the tube had been lying some time in syrup they became tolerably plain. At the free end of the egg-tube are some solid-looking nuclei, about as large as the nuclei of the epithelial cells, and only differing from them in being more distinct, and possessing granular contents.

These nuclei are generally all about the same size; sometimes, however, one or two are larger than usual; and as this was the case in the first specimen I examined, I was inclined to believe that the nuclei increased in size, and thus became the Purkinjean vesicles. As I was not able in other specimens, however, to find any nuclei in the process of becoming Purkinjean vesicles, this view requires confirmation, though it is supported by the analogy of other animals.

Although in an unaltered condition the epithelial cells of the egg-tube are very faint, and often altogether invisible, yet if pure water be added and the syrup be removed, the cell-walls and the epithelial nuclei gradually become quite plain. Most of the cells are, from the apposition of their neighbours, irregular and somewhat angular in shape; here and there, however, we see one quite round, and these can scarcely be distinguished from the youngest Purkinjean vesicles. In the latter, however, the nucleus looks rather more solid. The smallest Purkinjean vesicle which I saw was $\frac{6}{8000}$ths of an inch in diameter.

The yelk of the young eggs appears to possess no vitelline membrane; nor, though the boundary of it is perfectly distinct, has it any definite shape, but, apparently in consequence of the pressure put upon it by its neighbours, the outline which it assumes is very variable. As, however, it continually increases in size, it gradually comes to occupy the whole width of the egg-tube, and then assumes generally a more or less wedge-like shape, the Purkinjean vesicle occupying the thicker end. There are usually three or four egg-germs in this stage (Plate XVII. fig. 37).

The two or three most advanced egg-germs approximated more or less to the form of the mature egg, and were darkened by the deposition of granules and small oil-globules.

Below the eggs was a yellow matter, corresponding apparently to the so-called corpora lutea found in the egg-tubes of insects.

The mature egg is elongated fusiform, about $\frac{9}{200}$ths of an inch in length, and enclosed in a tough, somewhat transparent chorion.

The Purkinjean vesicle, which in the smallest egg-germs was sometimes even less than $\frac{1}{1000}$th of an inch, increases to as much as $\frac{1}{140}$th of an inch in diameter. In the meanwhile the macula has undergone important changes.

I have already mentioned that on its first appearance it is a single, apparently solid body; but even in the smallest egg-germs the Purkinjean vesicle contains very often, besides the macula, a small vesicle, which increases in size with the macula, but otherwise undergoes no alteration (Plate XVII. fig. 40). In many cases, however, I could not see this secondary macula.

The macula itself soon appears to develope in its interior a clear space (Plate XVII. figs. 40, 41), which is apparently bounded by a membrane, since after a time it works its way to the surface of the macula, and forms a projection, and, indeed, sometimes appears to detach itself altogether from the macula. It is always quite clear and transparent, while the macula itself is turbid, though at this stage it again contains a clear space in its interior. I examined the Purkinjean vesicles of six full-grown eggs, but was unable to satisfy myself as to the normal state of their contents at this stage. All of them contained the large macula, which in some of them had the form of a hollow cap. Two of them had a second clear macula, about half as large as the first (Plate XVII. fig. 40); and one contained a number of small vesicles. These changes may be compared with what takes place in *Geophilus*.

The yelk consisted, as usual, of a viscid substance, containing fine granules and oil-globules, varying up to $\frac{1}{1000}$th of an inch in diameter. Acetic acid acted in the usual manner on these tissues, and dissolved all the granules contained in the free nuclei (which I supposed to be embryonic Purkinjean vesicles), just as it does the true macula.

Dilute ammonia also dissolves the macula and the granules of the free nuclei.

The spermatozoa have a minute pear-shaped head and a long tail. Taken from the testis of the male, they exhibit a wriggling movement.

General Remarks.

It appears that in the Annulosa, as in the other divisions of the animal kingdom, the Purkinjean vesicle is the first-formed part of the egg, and that the yelk and vitelline membrane are subsequently deposited round them. This holds good (according, at least, to the various naturalists who have written on the subject) in most insects, in Crustacea, Spiders, *Lacinularia* and other Rotatoria, in *Hermella*, in *Oxyuris*, *Ascaris*, and the Nematoidea generally. Dr. ALLEN THOMSON, indeed*, extends this to the whole animal kingdom. "The germinal vesicle," he says, "is universally the first part of the ovum which makes its appearance; it does not appear to be nucleated or to possess its macula

* Article "Ovum," p. 133.

from the first in all instances, and this macula cannot, therefore, be regarded as the centre of its formation." Other naturalists, however, have given a very different account of the process of egg-development; and even Dr. THOMSON himself, in that part of the same article which refers to the Acalephæ, does not figure or describe the Purkinjean vesicle as appearing until the second stage. GEGENBAUR also gives a very similar account of what takes place in *Thaumantias*. He says, "One sees, moreover, often even in one and the same animal, that some of the cells filling the ovary increase in size, the membrane raises itself more considerably from the nucleus, and at this time molecules, generally arranging themselves round the nucleus, begin to differentiate themselves in the originally homogeneous cell-contents. Only two or three cells of the primitive ovarian parenchyme pass through these changes, and thus become egg-germs; their growth proceeds further and further, and the contents of the egg-cell now consist of a finely granular substance, in the centre of which a transparent nucleus (the germinal vesicle) lies imbedded." Among the Mollusca, according to a very accurate observer, M. LACAZE DUTHIERS, the egg of *Dentalium* arises from a modified epithelial cell, the nucleus of which becomes the Purkinjean vesicle. These instances, however, are foreign to our immediate subject; but even among the Annulosa similar observations are upon record. In describing the ovary of *Argulus*, LEYDIG* says, "The smallest eggs are clear round cells, whose vesicular nucleus contains many nucleoli. They alter themselves gradually into eggs, and pass slowly from a circular to an oval shape, &c." Again, in *Limulus*, GEGENBAUR† expressly describes and figures the egg as arising from the modification of a single epithelial cell, the nucleus of which becomes the germinal vesicle‡; and in *Cypris* the egg has been described as having a similar origin. In his paper on *Argas persicus*§, Dr. C. HELLER says, "In its original form the egg appears as a colourless cell, with a transparent vesicular nucleus and finely granular contents. In more advanced eggs the finely granular mass is in greater quantity, and of a yellowish colour; an evident germinal vesicle is now present, in which the round germinal spot is clearly visible." Finally, if MEISSNER is correct, the membrane of the original cell becomes the vitelline membrane also in *Mermis* and *Gordius*, and in some of the Nematoid worms.

If these observations, or any of them, are correct, it is evident that we have in the Annulosa, as even in the animal kingdom generally, two essentially distinct types of egg-development, since the original epithelial, or at least ovarian cell, which becomes the whole egg in *Argulus*, *Limulus*, *Argas*, *Mermis*, &c., forms in other cases only the Purkinjean vesicle; so that, taking the undifferentiated ovarian cells as our starting-point and standard of reference, the Purkinjean vesicle in certain animals corresponds to the whole egg in others. In other words, we can no longer regard the "eggs" of all Annulose animals as being homologous with one another, but we must consider that, as

* SIEBOLD and KÖLLIKER's Zeits. f. Wiss. Zool. 1850, p. iv.

† Anatomische Unters. eines *Limulus*, mit besonderer Berücksichtigung der Gewebe. Halle, 1858.

‡ *Loc. cit.* pl. 1. fig. 3.

§ Aus dem xxx. Bande des Jahr. 1858 der Sitz. der Math.-naturw. Cl. der Kais. Ak. Wien.

regards their origin and mode of development, the eggs of some (*Argulus*, *Limulus*, &c.) are homologous with the Purkinjean vesicles of others (*Oniscus*, *Ascaris*, &c.).

It is easy to convince oneself that the egg cannot be considered as a modified ovarian cell, at any rate in certain cases; and a single inspection of a female *Glomeris*, for instance, will leave no doubt upon this point. On the other hand, I was myself at first inclined to believe that the second process did occur in some animals. Thus in *Polydesmus complanatus* it seems at first sight evident that each of the minutest eggs is constituted by a cell whose nucleus forms the Purkinjean vesicle, and whose cell-wall gradually becomes the vitelline membrane. The same appearance is also represented by the young eggs of *Cryptops*, *Arthronomalus*, *Geophilus*, &c., and is sometimes seen also in those of *Iulus*; but in this latter genus it is easy to see, especially if pure water is used, that many, if not all, of the young eggs have in reality no vitelline membrane. In all the Chilopods I have, however, found scarcely a case in which the Purkinjean vesicle is not already surrounded by a spherical mass of clear yelk with a perfectly distinct border; in a few cases, indeed, I believe myself to have done so, and in others, in which a membrane is apparently present, it is easy to convince oneself that this is an illusion, since if a portion is cut off, the new surface equally appears to possess a distinct membrane.

On the whole, therefore, it seems probable that in *Argulus*, *Mermis*, &c., the youngest eggs yet observed may not have represented the earliest stage, but may have at an earlier period consisted only of the Purkinjean vesicle, and that the sharp edge of the yelk may have had the appearance of a true membrane. That no free Purkinjean vesicles were found with those which were already surrounded by yelk, may perhaps have depended on the state of the animals when they were discovered. Neither WAGNER nor STEIN found in the Neuroptera, Orthoptera, and Lepidoptera any Purkinjean vesicles which were not already surrounded by yelk; but Professor H. MEYER, who examined certain Lepidoptera in an earlier state, that is to say while still larvæ*, figures and describes certain cellular elements of the ovary, which subsequently become Purkinjean vesicles and surround themselves with yelk.

The same explanation cannot as yet be applied to *Limulus*; but the figure given† closely resembles the appearance presented by the eggs of Spiders, in which, however, according to WITTICH, V. CARUS, and LEUCKART, the original cell forms the Purkinjean vesicle, round which the yelk is subsequently deposited. We may therefore fairly wait for a confirmation of GEGENBAUR'S observations before we unhesitatingly adopt the explanation which he offers of the mutual relations of the egg and the epithelial cells.

If, however, we may admit that no essential difference has as yet been proved to exist in the eggs of Annulosa, so far as regards the relations existing between the Purkinjean vesicle and the original ovarian cell, it would still seem that in the relations between the former and the yelk two very different types of development must be recognized.

* Zeits. f. Wiss. Zool. 1849, vol. i. p. 191.

† *Loc. cit.* fig. 9.

In describing the so-called "winter-ova" of *Lacinularia socialis*, Professor HUXLEY says *, "It will be observed that all these authors consider the winter-ova, or ephippial ova, and the ordinary ova to be essentially identical, only that the former have an outer case. The truth is that they are essentially different structures. The true ova are single cells which have undergone a special development. The ephippial ova are aggregations of cells (in fact, larger or smaller portions, sometimes the whole of the ovary) which become enveloped in a shell, and simulate true ova." This aggregation of several cells (one of them putting on the appearance and fulfilling the functions of a Purkinjean vesicle, and the whole becoming enveloped in a shell) is, however, the ordinary and only method of egg-development in many animals. In the Trematode and Cestoid worms, and the greater number of the *Turbellaria*, the yelk and the Purkinjean vesicle are formed in two separate organs. In *Piscicola*, according to LEYDIG, the mature egg contains, besides the Purkinjean vesicle and the ordinary yelk, a number of nucleated cells †.

In the Mites and Spiders, in *Chelifer*, *Obisium*, the Phalangidæ, and, so far as I know, all the Arachnida, the egg is the product of a single cell.

On the other hand, we find that complex eggs alone are present in vast numbers of insects, namely, in all the Lepidoptera, Diptera, Neuroptera (excluding the Libellulidæ and allied genera), Hymenoptera, Hemiptera, Homoptera, and Coleoptera. We are as yet ignorant of the mode of egg-development in the Thripsidæ and the Strepsiptera; nor does it seem quite clear whether the development of the pseudovum in *Aphis* can be referred to the complex type. It would appear, however, from the statements of HUXLEY, LEYDIG, and LEUCKART, that in the opinion of these three eminent naturalists the pseudovum is a derivative of a single ovarian cell, and differs therefore in this respect from the ovum of the impregnated female.

We know little as yet about the early stages of egg-formation in the Crustacea; but it would appear that the simple mode prevails generally throughout this class, with the exception of the Daphnidæ.

As regards the Rotatoria, the so-called winter-eggs have been observed in *Hydatina*, *Brachionus*, and *Notommata*, as well as in *Lacinularia*; and we may probably conclude that in these and other allied genera the development of these eggs is on the same type, while "summer-eggs," again, are formed from one cell.

Among the Myriapoda the eggs of *Lithobius*, *Cryptops*, *Geophilus*, *Arthronomalus*, *Polydesmus*, and *Iulus* are probably simple. At least I am disposed to think that the vitelline vesicle is homologous with the yelk-nucleus of spiders; but I have not yet been able to ascertain this point satisfactorily.

Glomeris, however, offers apparently an exception to the rule so general among the Myriapods, as the large rounded bodies present in the egg-capsule (Plate XVI. figs. 1, 2) are probably homologous with the vitelligenous cells of insects.

* Microscopical Journal, vol. i. p. 14.

† Zeit. f. Wiss. Zool. 1849, pt. 1. pl. 10. fig. 56.

In excluding the ephippial ova from the category of true eggs, Professor HUXLEY was influenced to a certain extent by the supposition that they are fertile without impregnation, and are therefore "not ova at all in the proper sense, but peculiar buds." According to STEIN, however, the reverse is probably the case, and the summer-eggs are agamic, while the winter-eggs require to be fertilized*. However this may be, the development of the eggs of insects sufficiently proves that eggs composed of several ovarian cells, like those which are unicellular, generally are incapable of development without impregnation. But no one can deny the name of true eggs to the ova of Butterflies, &c.; and we cannot, therefore, class as "false eggs" those which arise from more than one cell. Perhaps it would be better to distinguish the two classes as "compound" and "simple" or "unicellular." The names we may adopt are, however, of less importance than the establishment of the fact that throughout the Annulosa there are two sorts of eggs, which are of an essentially different structure, and cannot, therefore, strictly speaking, be regarded as homologous with one another.

It is also worthy of notice that among the Articulata a few species possess two sorts of eggs. The cases are indeed few; but as they are also far between (*Lacinularia*, &c. among the Rotatoria, *Daphnia*, &c. among the Crustacea, and *Aphis*, *Coccus*, &c. among the Insects), we may perhaps see in them the last vestiges of a state of things which at a former period may have been general, or at least more common. It is true that the existence of two sorts of eggs is generally supposed to be connected with the presence of Agamogenesis; but this mode of generation may perhaps have had the effect of retaining a previously existing condition, rather than of originating a new and peculiar state of things. The cases of the Bee and of some Lepidoptera prove that a double method of egg-development is no necessary condition of Agamogenesis.

Passing on to the other sex, I am not competent to offer any opinion as to the relations of the male and female elements to one another, or the homologies existing between the product of the male, the semen, on the one hand, and the egg or any part of it on the other; but it is remarkable that, as we find (if I am correct in the view now advanced) in the Annulosa eggs of two different sorts, so also there are traces of a similar bimorphism of the semen. In *Notommata Sieboldii*, according to LEYDIG, the spermatozoa are of two sorts; ZENKER has made the same observation with reference to *Asellus aquaticus*†, in which animal I have also convinced myself of this curious fact; and among Mollusca there is the well-known case of *Paludina vivipara*.

STEIN‡ includes also in this category the Common Woodlouse, since while the three terminal tubules produce only hair-shaped spermatozoa, the matrix, or receptacle into

* This is also in accordance with the case of *Daphnia*. In this genus, as in Rotatoria, the "summer-eggs" are agamic, but it has not yet been conclusively proved that the "winter-eggs" of either require impregnation.

† It would appear that (see VAN BENEDEN, Recherches sur la Faune littorale de Belgique) the same is the case with the allied genus *Slabberina*.

‡ MÜLLER's Archiv, 1842.

which the tubules open, contains also large nucleated cells. I am bound, however, to admit that I much doubt whether these nucleated cells do really perform any part in the act of fertilization, since, though I know them well by sight, and though I have over and over again found the hair-shaped spermatozoa in the generative organs of the female, I have never met with any of the round cellular bodies in this situation.

In *Lithobius*, also, and *Geophilus*, STEIN* discovered, besides ordinary hair-formed spermatozoa, large cellular bodies, which he believes to be actively concerned in impregnation. But in the spermatic sacs of the female of *Lithobius pilicornis*, I found only the long hair-like sort; and it would appear, from what FABRE says†, that in the extraordinary silken nests discovered by him, and in which, reversing the usual order of things, the male lays its semen, that excellent observer found only the capillary spermatozoa.

The spermatophores of *Cryptops*, however, contain, besides the filiform spermatozoa, numerous oval bodies much resembling the spermatozoa of *Glomeris*; and though these may possibly have some function like that which has been attributed to the second sort of cells found in the spermatophores of the Calanoid Entomostraca, it has not yet been proved in either case that they are not homologous with spermatozoa. I may refer to what I have already said respecting *Chelifer* and *Obisium*‡, as tending to show that in these genera also a similar state of things exists.

I believe there are no other animals among the Annulosa in which two sorts of spermatozoa are at present known to occur; but it is evident that there may be many in which the difference, being slight, has not been observed; without, however, pushing this argument too far, it may fairly be doubted whether we are justified in assuming that the hair-shaped spermatozoa of Isopods, Insects, and Chilognaths are strictly homologous with the more or less spherical spermatozoa of most Crustacea and of the Chilopods; and whether it would not be more correct to correlate the hair-shaped forms with the similarly-shaped spermatozoa of *Lithobius*, *Asellus*, &c., and the cellular types with the less-elongated bodies found in the male generative organs of these interesting genera.

When two sets of spermatozoa are present, it is not unreasonable to suppose that their functions are different, and it would be of the highest interest to ascertain wherein this difference consists. The question has often occurred to me whether the two sorts of spermatozoa produce embryos of different sexes. It seems to be satisfactorily ascertained that the sex of the Hive-bee depends on the impregnation of the egg, though, on the other hand, no such connexion appears to exist in *Psyche*. In the Hive-bee the unimpregnated egg produces only a male embryo. But if in any species the reverse were the case, and the unimpregnated egg always produced females, and if, further, at any one time it so happened that no males nor any impregnated females were in existence, it is evident that the male sex would be extinct for ever. Such cases we have perhaps in the species of the genus *Cynips*, although in spite of the great amount of negative evidence, it is difficult not to believe that the males do really exist in this genus, and will sooner or later be discovered.

* *Loc. cit.* p. 252.

† *Loc. cit.* p. 305.

‡ On a future occasion I shall attempt to show that the same is the case with the Sminthuridæ.

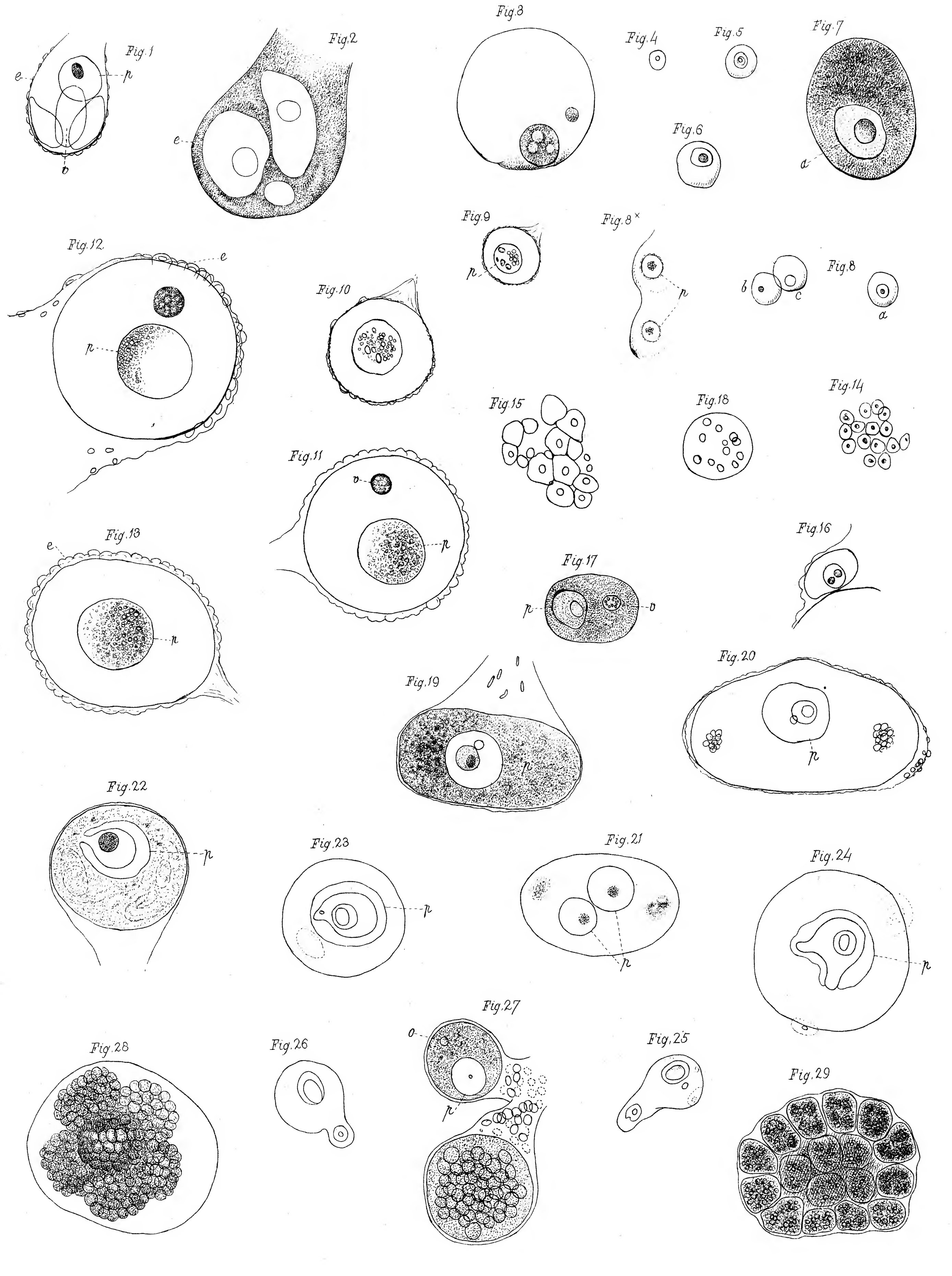
Explanation of the Plates.

PLATE XVI.

Fig. 1. Egg-follicle of *Glomeris marginata.* ×250.
Fig. 2. Another of *Glomeris marginata.* ×250, under the influence of dilute acetic acid.
Fig. 3. Purkinjean vesicle of *Glomeris marginata.* ×250.
Fig. 4. Young egg of *Polydesmus complanatus.* ×250.
Fig. 5. Young egg of *Polydesmus complanatus*, more advanced. ×250.
Fig. 6. Young egg of *Polydesmus complanatus*, more advanced. ×250.
Fig. 7. Young egg of *Polydesmus complanatus*, more advanced. ×250.
Fig. 8. Two very young Purkinjean vesicles of *Lithobius.* ×250.
Fig. 9. Young egg of Purkinjean vesicles of *Lithobius.* ×250.
Fig. 10. Young egg of Purkinjean vesicles of *Lithobius*, more advanced. ×250.
Fig. 11. Young egg of Purkinjean vesicles of *Lithobius*, more advanced. ×250.
Fig. 12. Young egg of Purkinjean vesicles of *Lithobius.* ×250.
Fig. 13. Young egg of Purkinjean vesicles of *Lithobius.* ×250.
Fig. 14. Epithelial nuclei on the general surface of the ovary. ×250.
Fig. 15. Epithelial cells on the egg-follicles. ×250.
Fig. 16. Young egg of *Arthronomalus.* ×250.
Fig. 17. Young egg of *Arthronomalus*, more advanced. ×60.
Fig. 18. So-called "yelk-nucleus" of *Arthronomalus.* ×250.
Fig. 19. Young egg of *Cryptops.* ×250.
Fig. 20. Young egg of *Cryptops*, more advanced. ×250.
Fig. 21. Young egg of *Cryptops*, with two Purkinjean vesicles. ×250.
Fig. 22. Young egg of *Geophilus.* ×250.
Fig. 23. Young egg of *Geophilus.* ×250.
Fig. 24. Young egg of *Geophilus.* ×250.
Fig. 25. Purkinjean vesicle of *Geophilus.* ×250.
Fig. 26. Purkinjean vesicle of *Geophilus.* ×250.
Fig. 27. Two egg-follicles of *Chelifer.* ×250.
Fig. 28. Egg of *Chelifer* undergoing segmentation. ×250.
Fig. 29. Egg-capsule of *Chelifer.* ×60.

PLATE XVII.

Fig. 30. Secretory organ of *Chelifer*. $\times 30$.
Fig. 31. Testis of *Chelifer*. $\times 30$.
Fig. 32. Mass of spermatozoa of *Chelifer*. $\times 250$.
Fig. 33. Contents of testis. $\times 250$.
Fig. 34. Contents of testis of *Obisium*. $\times 250$.
Fig. 35. Contents of testis of *Chelifer*. $\times 250$.
Fig. 36. Secretory organs of male *Chelifer*. $\times 60$.
Fig. 37. Two egg-tubes of *Petrobius maritimus*. $\times 30$.
Fig. 38. Nuclei from free end of *Petrobius maritimus*. $\times 250$.
Fig. 39. Young egg of *Petrobius maritimus*. $\times 250$.
Fig. 40. Purkinjean vesicle, more advanced. $\times 250$.
Fig. 41. Purkinjean vesicle, more advanced. $\times 250$.
Fig. 42. Purkinjean vesicle, more advanced. $\times 250$.
Fig. 43. Purkinjean vesicle, more advanced. $\times 250$.
Fig. 44. Youngest Purkinjean vesicles of *Oniscus*. $\times 250$.
Fig. 45. Testis and vas deferens of *Phalangium cornutum*.
A. Diagram of ovary of *Glomeris*.
B. Diagram of ovary of *Coccus*.
C. Diagram of ovary of *Phalangium*.



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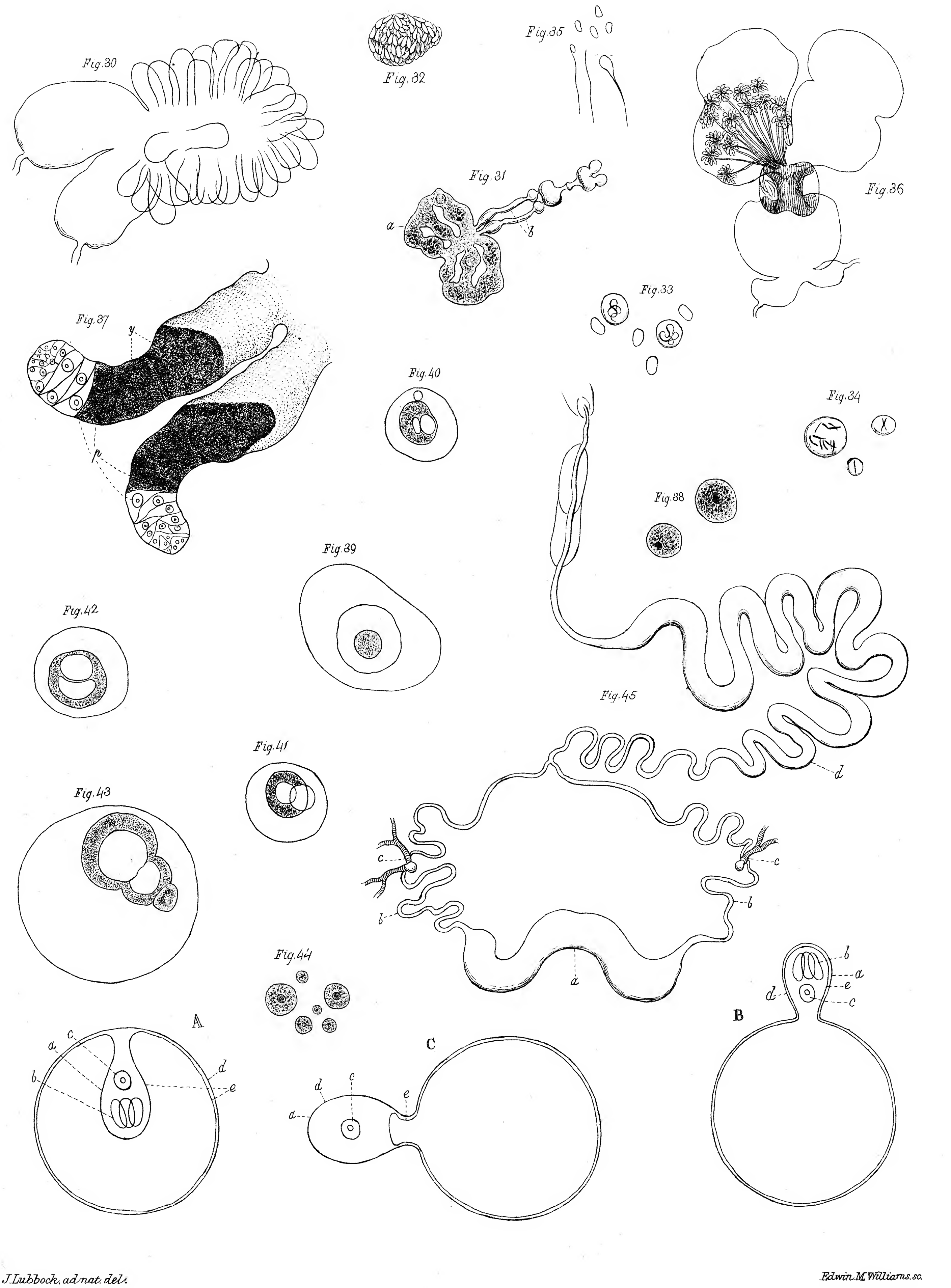

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